DOE/EERE Planning, Budget, and Analysis *(Revised)*

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DOE Hydrogen, Fuel Cells, and Infrastructure Technologies Program

Systems Analysis Workshop

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Charter

- ***PBA's mission:*** *to estimate the benefits of EERE programs in a consistent and defensible way.*
- ***Benefit Group's mission:*** *to estimate the demand for hydrogen fuel cell vehicles and the resulting impacts of their market penetration in competition with an advanced hybrid vehicle.*
- ***Analysis Group's current/past funding sources:*** *PBA funds for cross-cutting technologies and market analysis.*

History

- *History of and how long PBA has been doing analysis in general*
  - *PBA formed in 2002: lots of analysis had been performed by individual analysts prior to joining PBA*
- *List significant past analysis projects (i.e., those no longer being worked on)*
  - *2050 Transportation Study: started in 1997 and completed in 2003:*

  http://www.eere.energy.gov/office_eere/ba/future.html
- *History and how long you've considered hydrogen in your analyses*
  - *VISION: started in 2000*
  - *Regional H2 Model: started in 2003*
  - *GREET: started in 1995, hydrogen was included in this version*
  - *Hydrogen in NEMS: started 2003*
  - *GIS to help regionalize EERE models: started in 2004*
  - *EERE NEMS: started in 2000*
  - *EERE MARKAL: started in 2001*
  - *HyTrans: started 2002*

Skill Set - People

- *Past analysts who helped develop our capabilities: David Greene and Paul Leiby (ORNL), Margaret Singh, Dan Santini, Marianne Mintz, Steve Plotkin, Michael Wang, and Anant Vyas (ANL), Jim Moore (TAE), Frances Wood (OnLocation), and Chip Friley (BNL)*
- *Current analysts and their primary roles: same as above. They conduct and review the analysis projects described later.*

Skill Set – Models

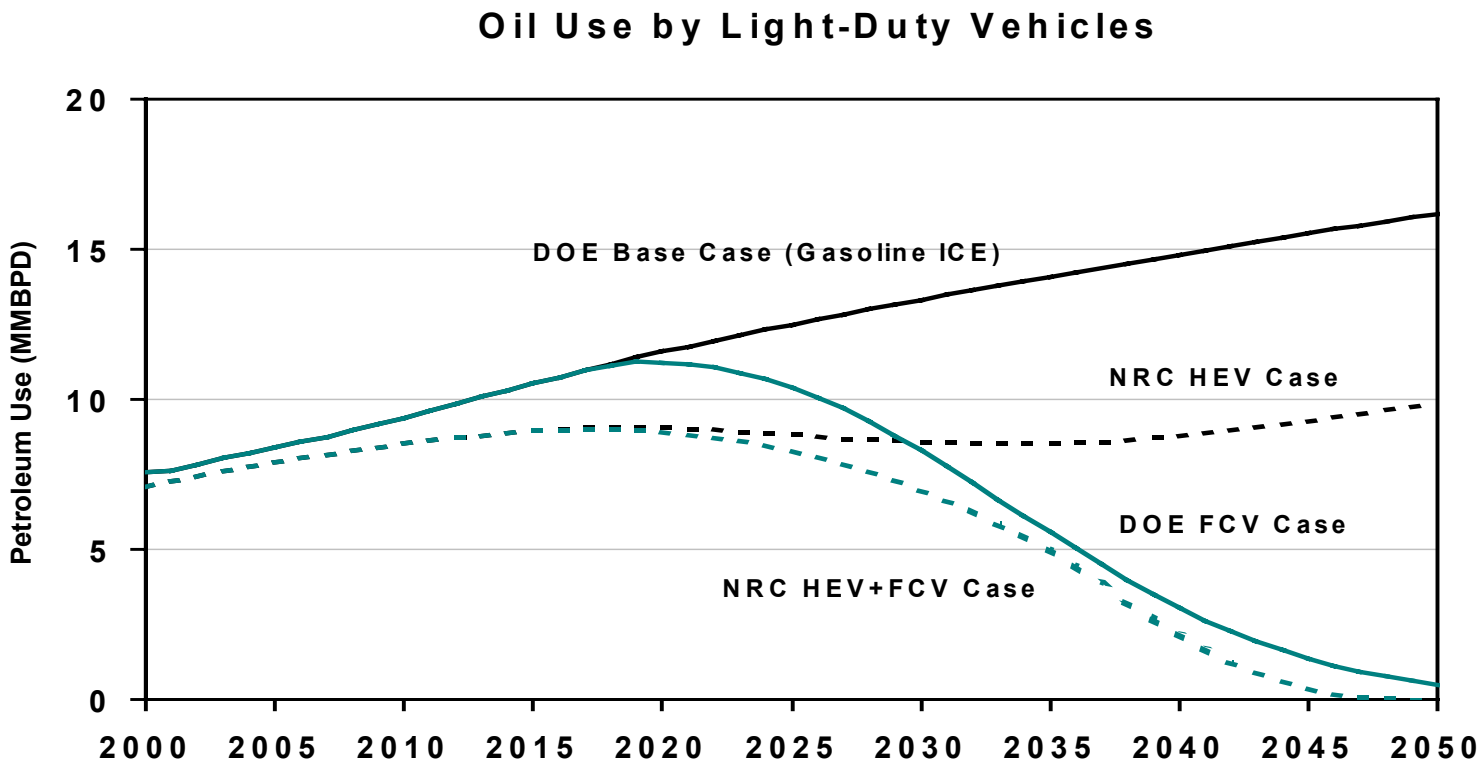
VISION

- *Modeling methodology: Vehicle stock model that uses NEMS assumptions to 2025 and extends them to 2050. It generates fuel use and carbon emissions.*
- *Model platform: Excel spreadsheet*
- *Model limitations: It is a "what if" model that allows the user to make any assumptions they wish with respect to how fast a new vehicle penetrates the market, the fuel it uses, and how efficient it is. Does not generate market penetrations.*

VISION MODEL: H2 PATHWAYS

- *Two H2 pathways in VISION model: natural gas and renewables*
- *Used in developing estimates of carbon emissions from light vehicle stock*
- *Carbon coefficients for these two pathways can be modified*
- *Carbon coefficients of other H2 pathways can be substituted*
- *Model is available on the ANL website: http://www.vision.anl.gov/*

VISION Model: Example Illustrating the Potential Benefits of FCVs



- DOE results are from VISION. Compared here to two National Academies cases. This has been used by Garman and Moorer in Congressional testimony and at SAE.

Skill Set – Models

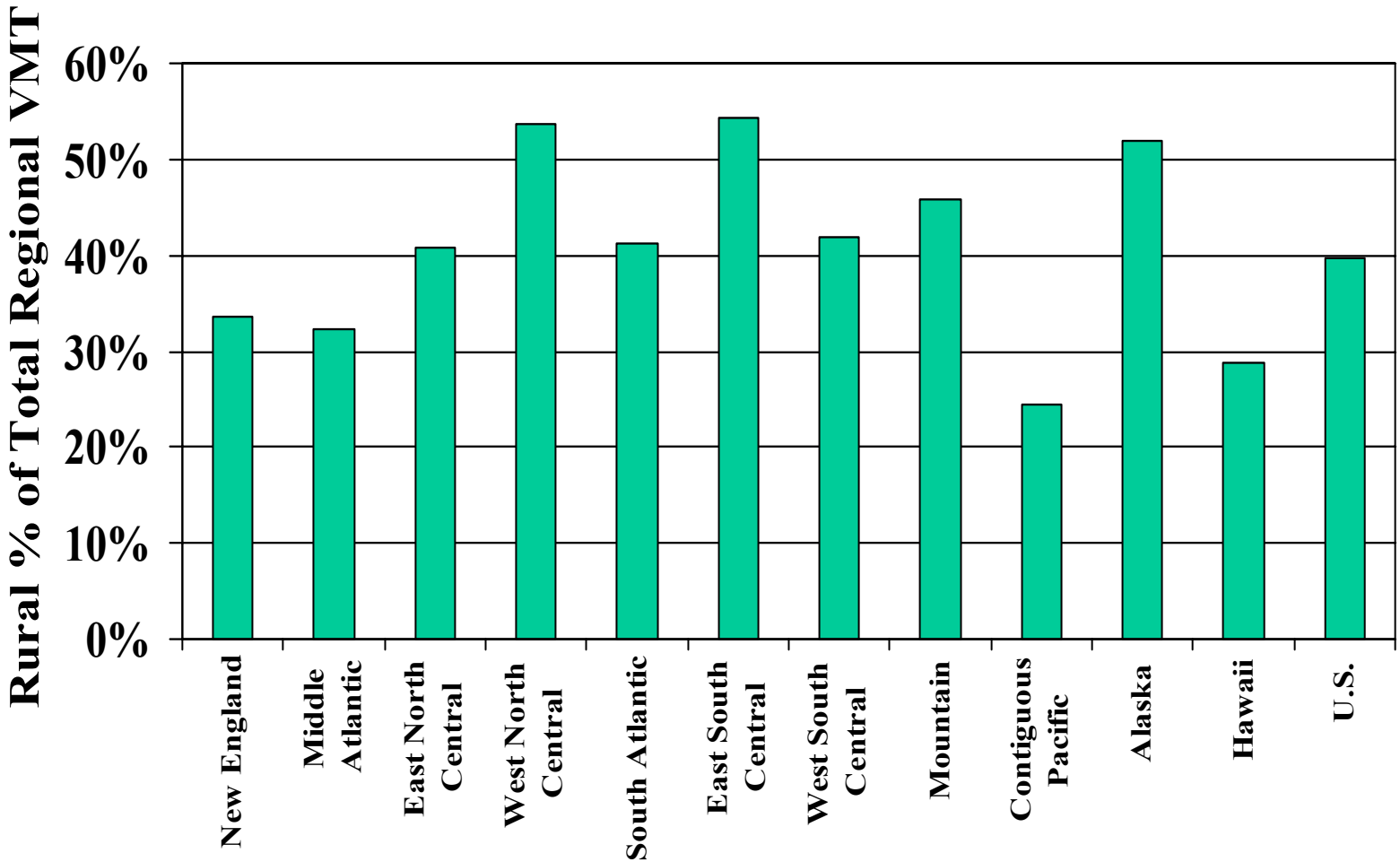
Regional H2

- *Modeling methodology: demand estimation, resource availability, and cost estimation by Census regions*
- *Model platform: Several Excel spreadsheets*
- *Model limitations: No optimization, no inter-regional trading of H2, does not include H2A costs*

Regional H2 Model

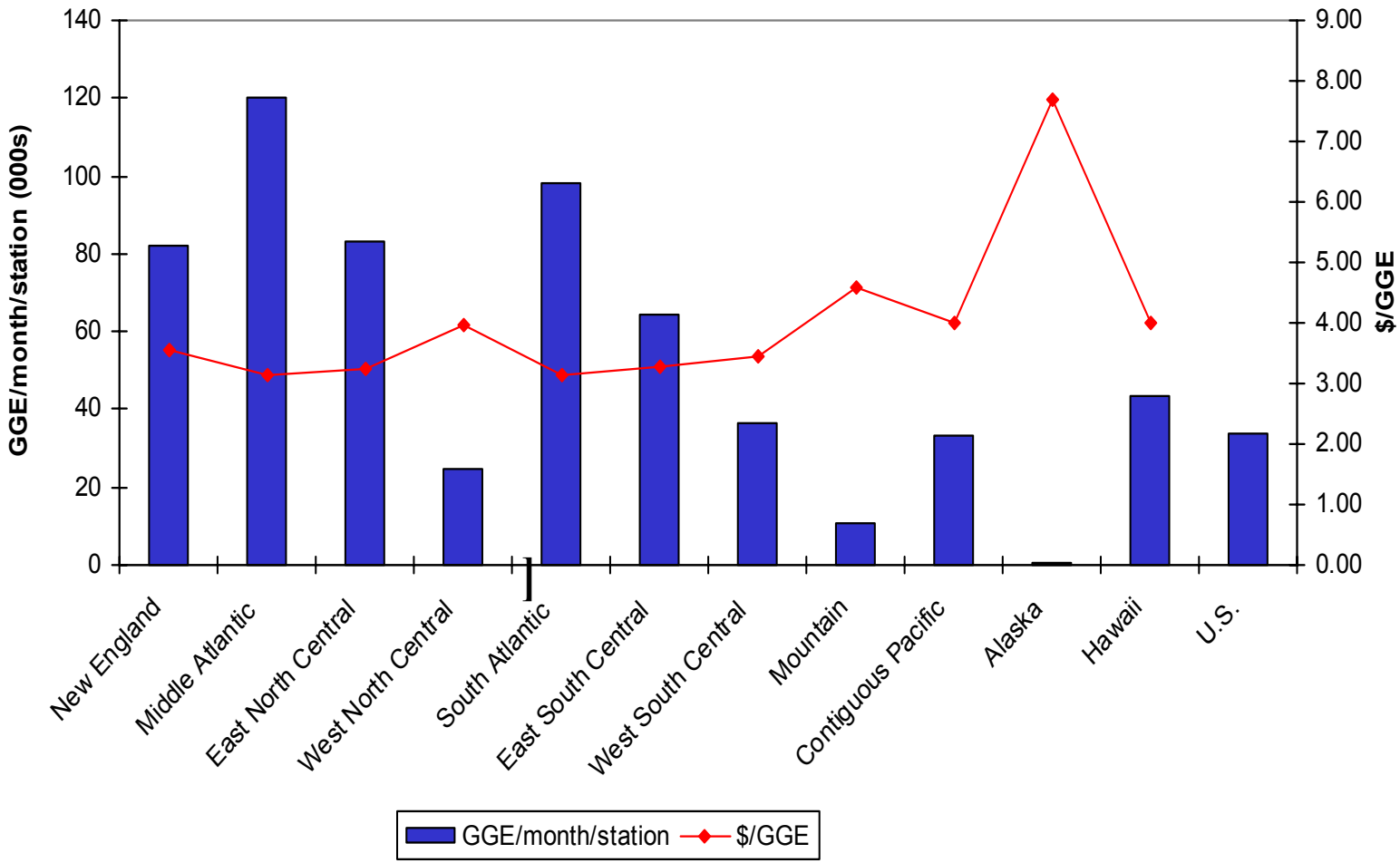
- *Cost estimates have been developed for the following pathways, by region:*
  - *Centralized H2 production from:*
    - *Natural gas, coal, biomass and off-peak electricity (detailed)*
    - *Nuclear, wind, and solar (placeholders)*
  - *Distributed H2 production from:*
    - *Natural gas*
    - *Electrolysis*
- *The current estimates will be updated with H2A results*

There Is Substantial Regional Variation in Rural Travel



Regional Variation in Size and Costs Estimated for Rural H2 Stations:

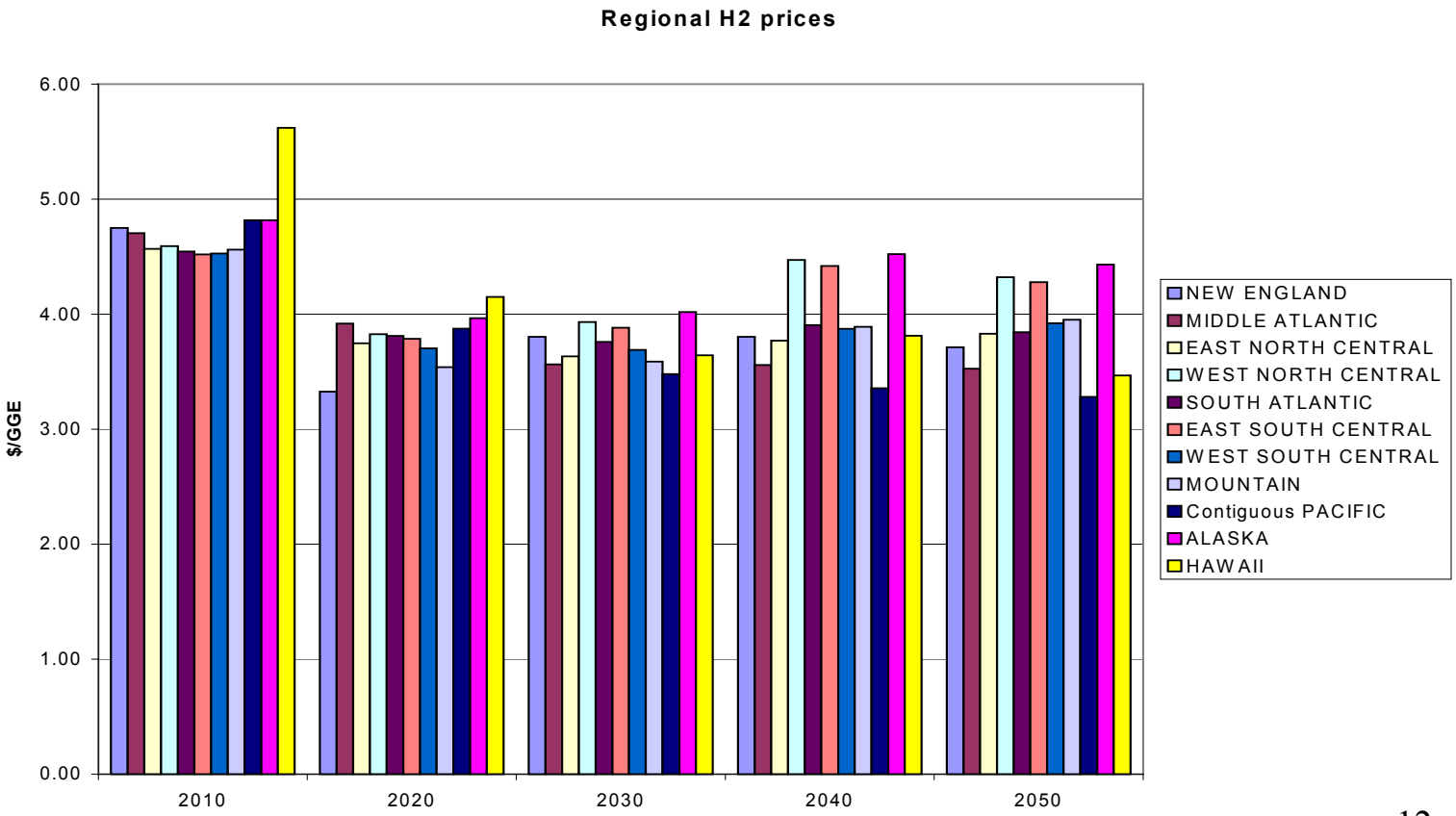
(Cost = Cost of Distributed H2 Production from Natural Gas, 2050)



H2 Costs Vary Across Regions and Over Time

(Figure Assumes that 50% of Rural Travel Is Served by Distributed H2 Production)

These hydrogen prices will be used by EIA in the 2005 Annual Energy Outlook



Skill Set – Models

GREET

- *Modeling methodology: full fuel-cycle analysis*
- *Model platform: Excel spreadsheet*
- *Model limitations: Not all pathways for H2 production have been added*
- *GREET has over 100 current users around the world*
- *Available on ANL website: http://www.transportation.anl.gov/greet/*

GREET Includes Many H2 Production Pathways and Vehicle Applications

- *Production from natural gas (central plant and distributed, from North American gas and non-North American gas)*
- *Production from electricity at refueling stations (U.S. average electricity, CA average electricity, and individual power plant types)*
- *Production from solar energy via photovoltaic*
- *Production from biomass (thermochemical processes with cellulosic biomass)*
- *Production from nuclear energy (electrolysis with nuclear power, and thermochemical processes of water cracking with high-temperature nuclear reactors)*
- *Production from coal (gasification) [under development]*
- *Production via fuel processors*
  - *On-vehicle production: ethanol, methanol, and gasoline*
  - *Station production: ethanol and methanol [under development]*
- *Both gaseous and liquid H2 are included; metal hydride and chemical storage are not included yet*
- *Vehicle applications for using hydrogen*
  - *ICE vehicles*
  - *ICE hybrid vehicles*
  - *Fuel-cell vehicles*

Skill Set – Models

H2 Module in NEMS

- *Analysis Requirements paper from contractor (OnLocation) received July 16*
- *Staged development suggested*
- *H2 module could eventually look like the electricity module*
- *Regional variations to be considered*
- *Co-production of H2 and electricity*
- *Some details in NEMS will not carry over to the H2 module (40 different coal types will be reduced to 3 initially)*

Skill Set – Models

Regionalization of EERE Models with GIS

- *Goals/objectives: Develop regional modeling capability with GIS tools and apply it to EERE integrating models*
  - *Apply to NEMS, MARKAL and other models*
  - *Apply in order to obtain improved benefits estimates*
- *This is a new project in 2004*
- *One of first applications: H2 technology*
  - *Development of H2 infrastructure will be highly dependent on resource distribution and location/size of end-use markets*
  - *Models with GIS data could be used to examine the lowest cost strategy (and alternatives) for building H2 infrastructure*

GIS and Regionalization Project

- *Project to identify best practices and gaps, and develop regional modeling capability for EERE.*
- *GIS and Regionalization Program Scoping Workshop held July 15-16, 2004 in Golden, CO. Presentations by labs and others of the regional aspects of the models. Also addressed several framework questions.*
  - *"Are there regionality issues and requirements unique to hydrogen, biomass, distributed generation, wind, etc."*
  - *What are the different levels of regionality used in different models, and should there be consistency in regional data?"*
  - *Can regional data be assembled and organized to enable such data to be aggregated and nested across different levels of detail for demand and supply."*

Development of Regional MARKAL for EERE GPRA Analysis - Objectives

- Enhance the current model structure to measure the market impact of technologies and policies sensitive to regional:
  - resource supply characteristics (fossil and renewable)
  - economic and demographic statistics/projections
  - energy end-use pattern and intensities
- Introduce inter- and intra- regional capacity and costs in energy transportation and distribution:
  - central transmission of electricity to load centers
  - energy supply infrastructure (e.g., gas pipelines)
  - options

Approach, Activities, and Schedule

Steps

Phase 1 - FY05	Phase 2 - FY06	Phase 3 - FY07
Development of a single census-region MARKAL	Development of a full multi-region MARKAL for U.S.	Application of model to EERE GPRA Analysis
Peer review of data and analysis	Baseline Calibration to AEO and NEMS	Program input and scenario development
Model improvement - structure & data	Peer review, test runs, and documentation	Generation of GPRA analysis with regional characterizations

Skill Set – Capabilities Summary

(Refer to H_2 Analysis Types – last Slide)

TYPE OF ANALYSIS	RESIDENT CAPABILITY?	STUDIES SPECIFIC TO H_2?	MODELS SPECIFIC TO H_2?
Resource Analysis	*Yes*	*No*	*No*
Technoeconomic Analysis	*Yes*	*No*	*No*
Environmental Analysis	*Yes*	*No*	*No*
Delivery Analysis	*Yes*	*Yes*	*Yes*
Infrastructure Development Analysis	*Yes*	*No*	*No*
Energy Market Analysis	*Yes*	*Yes*	*Yes*

Future

- *PBA will attempt to maintain its analytical capability*
- *PBA will decrease its funding for HyTrans as the effort switches from model building to model use and will seek funding from HFCIT*
- *Continue support of adding H2 module to NEMS and seek funding from FE, NE, and EIA*
- *Explore the use of GIS*
- *PBA will work with the Fossil Energy Office in DOE to create scenarios that will offer different futures in which H2 can have an impact*

Analysis Issues: Rural H2 Concerns

- *What portion of today's gasoline is purchased in rural markets (i.e., is VMT a good surrogate for fuel sales in rural areas)?*
- *What is the current number of rural gasoline stations by volume dispensed by population density or land area?*
- *What proportion of rural gasoline stations are located in close proximity to one another, perhaps allowing just one station to dispense an alternative fuel such as H2?*
- *How many rural interstate refueling facilities are there and what are the distances between them?*
- *How far do rural residents travel for fuel?*
- *Are there differences in the answers to the above questions between rural areas contained in metropolitan statistical areas (MSAs) and those outside MSAs?*
- *What options are there for delivering H2 to rural areas?*
- *Will H2 be supplied by a single provider or by multiple providers?*

Other Analysis Issues

- *If H2 is provided initially by distributed production in urban areas, could it remain the primary source of H2 in the long-run?*
- *How many years will it take to estimate H2 regional supply curves?*
- *What is the practical longest distance that H2 might be transported by mode?*
- *What is the likely sequence for H2 to be introduced across regions? Will it be in the California region first, then New England and the Mid-Atlantic (NY, NJ and PA), then the rest of the country with the Mountains, Upper Midwest and Alaska being last?*
- *Should metal hydride and chemical storage be included in GREET?*